Real Time Control of Surface Irrigation: Managing Infiltration Variations and Enhancing Furrow Irrigation Performance

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Introduction

The performance of surface irrigation is a function of the field design, infiltration characteristic of the soil, and the irrigation management practice. However, the complexity of the interactions makes it difficult for irrigators to identify optimal design or management practices. The infiltration characteristic of the soil is the most crucial of all the factors affecting the performance of surface irrigation and both spatial and temporal variations in the infiltration characteristic are a major physical constraint to achieving higher irrigation application efficiencies (1). Real time optimisation and control has the potential to overcome these spatial and temporal variations and return highly significant improvements in performance. A simple real time control system is proposed that provides infiltration information in real time and determines the cut off time for optimal performance.

Description of the Proposed System

The basis of the system is a new method (2) for predicting the soil infiltration characteristics for individual furrows from an infiltration curve of known shape (the model infiltration curve) and only one advance point measurement. The underlying hypothesis for the method is that the shape of the infiltration characteristic for a particular field or soil is relatively constant (across the field and with time), despite variations in the magnitude of the infiltration rate or amount.

A typical furrow in the field is selected for evaluation (known as the model furrow) and its infiltration parameters (*a, k, f_o*) in the Kostiakov–Lewis equation:

$$I = kt^a + f_o t$$

are determined by a model such as IPARM (3) using extensive inflow, advance and runoff data. Subsequently the infiltration parameters for this model furrow can be scaled to give the cumulative infiltration curves for the whole field. In this process a scaling factor *(F)* is formulated from rearrangement of the volume balance equation and is calculated for each furrow/event using the model infiltration parameters and the single advance point. The performance of each furrow can then be simulated and optimised using an appropriate simulation model to determine the preferred time to cut-off.

Evaluation

To evaluate the real time control system, two different cotton fields (T & C) were selected, from which irrigation water balance and advance data were available for a total of 42 furrow irrigation events. A furrow was selected as the model furrow for each field, and the real time control system as described above was applied (in retrospect).The actual irrigations for each furrow were simulated using the simulation model SIRMOD (4) to give the performance parameters (application efficiency, requirement efficiency and uniformity) for those irrigations. SIRMOD was then used with the scaled infiltration parameters to assess the performance of the real time control.

The results revealed that the infiltration curves produced by proposed method were of similar shape (Figure 1) and hence gave a distribution of cumulative depths of infiltration for the whole field that was statistically equivalent to that given using the complete set of advance data for each furrow. The advance trajectories produced by the proposed method also matched (Figure 2) favourably to the measured advances.

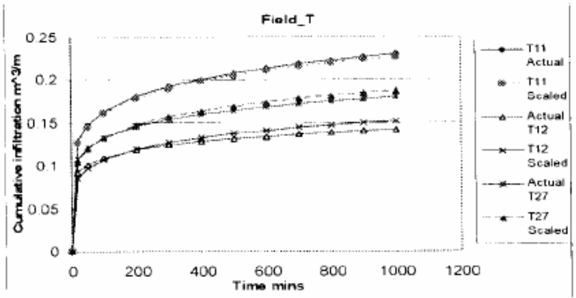

Figure 1 Example of scaled and actual infiltration curves

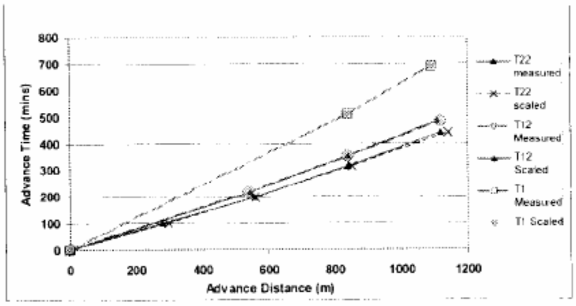

Figure 2 Example of measured and predicted advance trajectories

The simulation results showed firstly that the scaled infiltration gave predictions of the irrigation performance similar to the actual performance. They also indicated that by adopting the simple real time control system, irrigation application efficiencies for the two fields could be improved from 76% for field T and 38% for field C (under usual farm management) to 85% and 72% for the fields T & C, respectively. Reductions in the total volume of water applied to field T & C of 20% and 60% respectively were indicated, which can be used beneficially to grow more crop.

Conclusions

The proposed real time control system is shown to be feasible. It requires few data for its operation and provides the infiltration characteristics for each furrow without significant loss of accuracy. The irrigation performance is improved greatly from that achieved under current farmer management and a substantial reduction in the volume of water applied per irrigation is achievable.

References

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